

Chapter 17

Talking Hyoids and Talking Neanderthals

David W. Frayer

Abstract Yoel Rak and others published the first known Neanderthal hyoid bone in 1989. Contrary to expectations, the ~60 ka Kebara hyoid was completely within modern human variation and led them to conclude, “the assumed speech limitations of Neanderthals... would seem to require revision.” Subsequently two more fragmentary hyoid bones from Sima de los Huesos (Atapuerca), dating to over 400,000 years ago were determined to be not different from anatomically modern morphology. Most recently, the hyoid of the Dikika child (*Au. afarensis*), dated much earlier at ~3.3 Ma, was found to clearly resemble that of an ape. The time span represented by these three sites shows that at least part of the anatomy surrounding the vocal tract was of a modern morphology in Neanderthals and their likely ancestors, but not in the much earlier *Australopithecus*. It was the Kebara hyoid which marks the beginning of a modern understanding of Neanderthal speech capability. This paper reviews the controversy surrounding the interpretation of the Kebara hyoid and other evidence from fossil anatomy, archaeology and paleogenetic data accumulated since 1989, which convincingly shows that Neanderthals possessed the ability to speak like us.

Keywords Kebara cave • Language • Sima de los Huesos • Speech

In 1989, Yoel Rak announced with others the discovery of a hyoid bone associated with the Kebara 2 Neanderthal skeleton. This was the first hyoid found in a fossil hominid context and its morphology and metrics indicated that, unlike the associated mandible, the hyoid was completely modern. They concluded that “the assumed speech

limitations of the Neanderthals, that have hitherto been based primarily on studies of basicranial morphology, would seem to require revision” (Arensburg et al. 1989: 760) since the hyoid showed no fundamental differences compared to 67 modern hyoids. In a more detailed account, based on the Kebara hyoid’s modern-looking metrics and anatomy, Yoel and his colleagues concluded Neanderthals “appear to be as ‘anatomically capable’ of speech as modern humans.” (Arensburg et al. 1990: 145). And, in a *Current Anthropology* paper Yoel and others argued the modern morphology of the hyoid “strongly suggests that Middle Paleolithic hominids were equally capable of speech when hyoid positioning and supralaryngeal space are the criteria considered” (Bar-Yosef et al. 1992: 530). Thus, the discovery at Kebara completely changed the atmosphere about Neanderthal language capacity, and Yoel and his colleagues’ publications serve as a milestone in the slow acceptance of Neanderthals having language ability like modern humans.

Despite its significance, the Kebara 2 hyoid met with a barrage of skepticism by a few, especially those who had a history of denying Neanderthals the ability to speak like us. For example, just a decade earlier, in a review article, Laitman et al. (1979: 15) stated, “bony landmarks, such as the hyoid bone or styloid process which give clues to the position and shape of the upper respiratory structures are often missing.” One might have anticipated that Kebara 2 would have provided a welcome resolution for some issues about Neanderthal communicative abilities, but on the contrary, at the American Association of Physical Anthropologists meeting in Miami, Laitman et al. (1990: 254) claimed “[a]s we do not know what the hyoids of other fossil hominids looked like, it is possible that hyoid morphology was similar as far back as early members of *Homo*, if not earlier. If so, then the hyoid would be an irrelevant indicator of vocal tract evolution.” They further asserted, “hyoids of

D.W. Frayer (✉)
Department of Anthropology, University of Kansas, Lawrence,
KS 66044, USA
e-mail: frayer@ku.edu

mammals with vocal tracts clearly unlike those of modern humans also show metric features which would, by themselves, identify them as ‘human.’ For example, suid hyoids are metrically more similar to those of modern humans than Kebara.” The former assertion assumes its conclusion and the latter is demonstrably incorrect.

The implications of the Kebara hyoid also drew strong criticism from Lieberman (1992) who originally speculated (Lieberman and Crelin 1971; Lieberman et al. 1972) that Neanderthals could not have produced essential vowels “a”, “i” and “u.” Lieberman (1992) argued in detail that the modern looking Kebara hyoid tells nothing about the supralaryngeal space, since the Kebara 2 base was missing and other Neanderthal crania had flat cranial bases like apes. A similar denouncement of the hyoid’s importance was given in a *Nature* response (Lieberman et al. 1989) when the Kebara hyoid was first published (Arensburg et al. 1989; Marshall 1989). Here, Lieberman et al. (1989: 486) maintained in almost the identical sentences as above, that “[a]s we do not know what the hyoids of other fossil hominids looked like, it is possible that hyoid morphology was similar as far back as early members of *Homo*, if not earlier. If so, then the hyoid would be an irrelevant indicator of vocal tract evolution”.

In the intervening years more Neanderthal and pre-Neanderthal hyoids have been found, at El Sidrón cave (Rodríguez et al. 2002) and in the Sima de los Huesos at Atapuerca (Martínez et al. 2008), both in Spain. These bones, like the Kebara hyoid, are completely modern in their metrics and morphology and undeniably confirm that fossil *Homo* hyoids from Europe conform to the modern pattern. An apparent exception to this is the ‘hyoid’ from Castel di Guido, described by Capasso and D’Anastasio (2008), but the bone is now identified as the dorsal rim of a first cervical vertebra (Capasso et al. 2016). Interestingly, the hyoid associated with the 3.3 myr-old *Au. afarensis* child from Dikika differs significantly from the modern and fossil *Homo* condition. Comparing the morphology and metrics of the hyoid to gorillas, chimpanzees and living humans Alemseged et al. (2006) concluded the Dikika hyoid has corpus metrics completely outside the human range and completely within the ape range. The morphology of the Dikika hyoid suggests (Alemseged et al. 2006) that early *Australopithecus* had a vocal tract similar to apes with a functioning air sac. deBoer (2012) has argued that air sacs interfere with vowel-like articulations, and their presence in Dikika indicates it lacked modern human-like supra-laryngeal sound production.

Evidence for an air sac is clearly absent in any of the fossil European hyoids, which resemble neither Dikika nor suids. As for suids, their hyoids in actuality bear no relevant similarity to Kebara (Fig. 17.1). Twenty years ago I reported that suids have a tall/thick corpus and tall greater horns

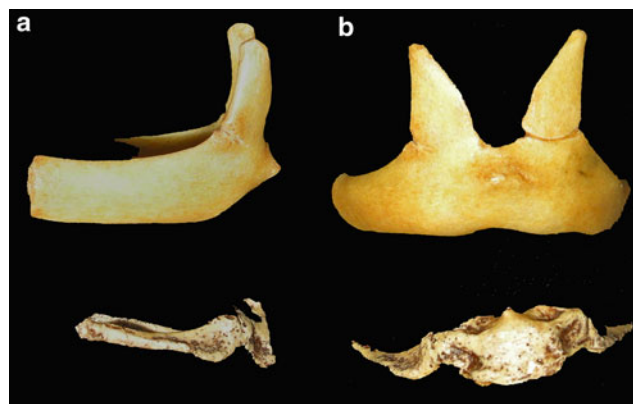


Fig. 17.1 Lateral (a) and anterior (b) views of a modern domestic pig (above) and Kebara 2 hyoid (below). The two show no anatomically or evolutionary relevant similar features

along with a large central tubercle and massive lesser horns. The anatomy and metrics of suids are not ‘more similar’ to Kebara (Frayer 1993). Whatever the logic of finding an affinity between a suid and the Kebara hyoid, any important similarity should be forever dismissed. This assertion by Laitman et al. (1992) violates what Le Gros Clark called the principle of morphological equivalence in making statistical comparisons, a mistake Le Gros Clark considered to be “one of the most serious sources of fallacy likely to affect statistical studies by those who are not thoroughly acquainted with the skeletal elements with which they are dealing” (Le Gros Clark 1964: 32).

While the hyoid reveals little about the supra-laryngeal space, if Neanderthal hyoids looked like apes or Dikika, an air sac would be a reasonable interpretation. Had this been the case, Neanderthals inarguably would have had vocal shortcomings. Most recently, d’Anastasio et al. (2013: 6) have confirmed Kebara 2’s similarity with moderns and commented on how this relates to a modern vocal tract. They write:

...the presence of modern-human-like histological features and micro-biomechanical behavior in the Kebara 2 hyoid indicates that this bone not only resembled that of a modern human, but that it was used in very similar ways.

So, despite assertions to the contrary, hyoid morphology does reveal something about the linguistic capacity of a hominid and the Kebara hyoid, along with others from Sima de los Huesos and El Sidrón are morphologically and histologically equivalent to moderns.

What about additional evidence for Neanderthal linguistic ability since the discovery of the Kebara hyoid? For this, there has been a sea change of new evidence from anatomy to archaeology to paleogenetics. We now know that reconstructions of the cranial base are not flat, but arched like in us (Heim 1989; Lieberman 1998; Boë et al. 1999, 2002;

Frayer and Nicolay 2000) and that the Neanderthal vocal tract is capable of producing vowels very similar or identical to modern Europeans (Barney et al. 2012; Dediu and Levinson 2013). We also know that Neanderthal ear ossicles are similar to modern humans, thanks again to Yoel's work (Quam and Rak 2008) and that modern auditory anatomy stretches back to more than 0.5 million years ago (Martínez et al. 2004).

Holloway (1985) argued that Neanderthal brains were lateralized like modern humans, a likely signature of language ability. Subsequent work by Holloway et al. (2005) stressed again the importance of paleoneurological data, which clearly showed that Neanderthals had brain lateralization and regional specialization like living people. Brain lateralization is a key component of language capacity and work by Gotts et al. (2013: 1) has confirmed with fMRI the importance of the left hemisphere in its "cortical regions involved in language and fine motor control."

Some of my joint work with Italian, French and Spanish colleagues has shown that Neanderthals and their likely European ancestors were predominately right-handed like modern humans based on obliquity of scratches found on the labial face of incisors and canines (Fig. 17.2; Frayer et al. 2012; Volpato et al. 2012). Since handedness is a reflection of laterality, our data from tooth scratches and Holloway's observations from endocasts are completely concordant. We also know that apes are not lateralized like humans and certainly not handed in the way of humans and Neanderthals (McGrew and Marchant 1997).

For archeological discoveries pointing to linguistic competence we know that Neanderthals had ornaments (Zilhão et al. 2010), decorated themselves with paint (Cârciumaru and Țuțuianu-Cârciumaru 2009), feathers (Soressi and d'Errico 2007; Peresani et al. 2011) and eagle talons (Morin and Laroulandie 2012; Radovčić et al. 2015), practiced seafaring (Ferentinos et al. 2012), had complex site structures (Henry et al. 2004; Vallverdú et al. 2010) with resource scheduling, including marine foods (Daujeard and Moncel 2010; Cortés-Sánchez et al. 2011). Consumption of plant materials has been documented through analysis of plant seeds and debris (Lev et al. 2005; Henry et al. 2010) based on starches preserved in dental calculus and residue on tools (Hardy and Moncel 2011). There is even evidence of Neanderthals consuming plants of no nutritional, but pharmacological, value (Hardy et al. 2012). Neanderthals made bone tools for leather working (Soressi et al. 2013), transported or exchanged raw materials over long distances (Slimak and Giraud 2007; Peresani et al. 2013) and had complex site arrangements as seen in moderns (Henry et al. 2004; Vallverdú et al. 2010). For ritual behavior there is no doubt they buried their dead of all ages (Maureille and Vandermeersch 2007; Pettit 2012) and at least in one site there appears to be other types of ritual treatment of the dead (Frayer et al. 2008).

But, perhaps, the most wondrous new evidence addressing language ability comes with discovery of Neanderthal nuclear DNA from a number of specimens and sites (Green et al. 2010). From these sequences we know that unique



Fig. 17.2 Four incisors from the Neanderthal mandible Regourdou, dated to OIS 4, ca. 70 ka. Obliquity of marks on the two lateral incisors and the right I_1 are typical of right-handed scratches found in many other Neanderthal teeth (Volpato et al. 2012). Arm chain remains from the skeleton more than 3 decades ago identified it as right-handed (Vandermeersch and Trinkaus 1995)

Neanderthal genes are found in at least 2–4% in living Europeans (Green et al. 2010), if not double this (Lohse and Frantz 2013). One of the genetic sequences is the FOXP2 gene. This gene is linked to language production, in that those who possess mutations in it have grammar, syntax and vocal deficiencies (Hurst et al. 1990; Lai et al. 2001) and numerous other factors affecting development. The fact that Neanderthals share two key FOXP2 nucleotide sequences with humans, which distinguish us from apes (Krause et al. 2007) completes the circle of evidence for Neanderthals having linguistic ability like us. Following paleogenetic estimates (Green et al. 2010), this marker of language capacity may extend back to more than 0.5 mya. This would make language old, not young as some have argued (Lieberman et al. 1972; Laitman et al. 1979; Diamond 1989).

Yoel's work on the Kebara hyoid triggered the re-thinking and re-analysis of the perception of Neanderthal vocal ability. Yoel and his colleagues concluded in their *American Journal of Physical Anthropology* (Arensburg et al. 1990: 145) article:

Hopefully the hyoid and related bones of other fossil hominids will be recovered in the future, and we believe this will add to our understanding of the vocal and upper respiratory organs of fossil humans.

One doubts he could have fully anticipated the chain of evidence now leading from this little bone in the throat to a full appreciation of the modern language capacities of Neanderthals.

Acknowledgement and Nota Bene Milford Wolpoff (Michigan) provided some important suggestions. As for Yoel, we first met in Berkeley in 1979. In those days the single species hypothesis as applied to *Australopithecus* was still being debated and Yoel wanted me to know for sure that what my adviser, Milford Wolpoff, wrote could not be correct. Since that time we have met many times at professional meetings or overseas and, while we often disagreed about some things, Yoel could not have been more congenial nor as courteously dismissive of my ideas. All my best to a first class person and scholar.

References

- Alemseged, Z., Spoor, F., Kimbel, W. H., Bobe, R., Geraads, D., Reed, D., et al. (2006). A juvenile early hominin skeleton from Dikika, Ethiopia. *Nature*, 443, 296–301.
- Arensburg, B., Tillier, A.-M., Vandermeersch, B., Duday, H., Schepartz, L. A., & Rak, Y. (1989). A Middle Paleolithic human hyoid bone. *Nature*, 338, 758–760.
- Arensburg, B., Schepartz, L. A., Tillier, A.-M., & Vandermeersch, B. (1990). A reappraisal of the anatomical basis for speech in Middle Paleolithic hominids. *American Journal of Physical Anthropology*, 83, 137–146.
- Bar-Yosef, O., Vandermeersch, B., Arensburg, B., Belfer-Cohen, A., Goldberg, P., Laville, H., et al. (1992). The excavations in Kebara, Mt. Carmel. *Current Anthropology*, 33, 497–550.
- Barney, A., Martelli, S., Serrurier, A., & Steele, J. (2012). Articulatory capacity of Neanderthals, a very recent and hominin-like fossil. *Philosophical Transactions of the Royal Society B*, 367, 88–102.
- Boë, L.-J., Maeda, S., & Heim, J.-L. (1999). Neanderthal man was not morphologically handicapped for speech. *Evolution of Communication*, 3, 49–77.
- Boë, L. J., Heim, J.-L., Honda, K., & Maeda, S. (2002). The potential Neanderthal vowel space was as large as that of modern humans. *Journal of Phonetics*, 30, 465–484.
- Cârciumaru, M., & Țuțuianu-Cârciumaru, M. (2009). *L'ocre et les récipients pour ocre de la grotte Cioarei* (pp. 7–19). XI: Annals d'Université Val Targ.
- Capasso, L., Michetti, E., & D'Anastasio, R. (2008). A *Homo erectus* hyoid bone: Possible implications for the origin of the human capability for speech. *Collegium Anthropologicum*, 32, 107–112.
- Capasso, L., d'Anastasio, R., Mancini, L., Tuniz, C., & Frayer, D. W. (2016). New evaluation of the Castel di Guido 'hyoid.' *Journal of Anthropological Sciences*, 94, 231–235.
- Cortés-Sánchez, M., Morales-Muiz, A., Simón-Vallejo, M. D., Lozano-Francisco, M. C., Vera-Peláez, J. L., Finlayson, C., et al. (2011). Earliest known use of marine resources by Neanderthals. *PLoS ONE*, 6, e24026.
- D'Anastasio, R., Wroe, S., Tuniz, C., Mancini, L., Cesana, D. Y., Dreossi, D., et al. (2013). Micro-biomechanics of the Kebara 2 hyoid and its implications for speech in Neanderthals. *PLoS ONE*, 8, e82261.
- Daujeard, C., & Moncel, M.-H. (2010). On Neanderthal subsistence strategies and land use: A regional focus on the Rhone Valley area in southeastern France. *Journal of Anthropological Archaeology*, 29, 368–391.
- deBoer, B. (2012). Loss of air sacs improved hominin speech abilities. *Journal of Human Evolution*, 62, 1–6.
- Dediu, D., & Levinson, S. (2013). On the antiquity of language: The re-interpretation of Neanderthal linguistic capacities and its consequences. *Frontiers in Psychology*, 4, 1–17.
- Diamond, J. (1989). The great leap forward. *Discover Magazine*, 10, 50–60.
- Ferentinos, G., Gkioni, M., Geraga, M., & Papatheodorou, G. (2012). Early seafaring activity in the southern Ionian Islands, Mediterranean Sea. *Journal of Archaeological Science*, 39, 2167–2176.
- Frayer, D. W. (1993). The Kebara 2 hyoid only resembles humans. *American Journal of Physical Anthropology, Supplement*, 16, 88.
- Frayer, D. W., & Nicolay, C. (2000). Fossil evidence for the origin of speech sounds. In N. L. Wallin, B. Merker, & S. Brown (Eds.), *The origins of music* (pp. 217–243). Cambridge: MIT Press.
- Frayer, D. W., Orschiedt, J., Cook, J., Russell, M. D., & Radović, J. (2008). Krapina 3: Cut marks and ritual behavior? In J. Monge, A. Mann, & D. W. Frayer (Eds.), *New insights on the Krapina Neanderthals: 100 years after Gorjanović-Kramberger* (pp. 285–290). Zagreb: Croatian Natural History Museum.
- Frayer, D. W., Lozano, M., Bermúdez, de Castro J.-M., Carbonell, E., Arsuaga, J.-L., Radović, J., et al. (2012). More than 500,000 years of right-handedness in Europeans. *Laterality*, 17, 51–69.
- Gotts, S. J., Jo, H. J., Wallace, G. L., Ziad, S. S., Cox, R. W., & Martin, A. (2013). Two distinct forms of functional lateralization in the human brain. *Proceedings of the National Academy of Sciences USA*, 110, 3435–3444.
- Green, R. E., Krause, J., Briggs, A. W., Maricic, T., Stenzel, U., Kircher, M., Patterson, N., et al. (2010). A draft sequence of the Neanderthal genome. *Science*, 328, 710–722.
- Hardy, B. L., & Moncel, M.-H. (2011). Neanderthal use of fish, mammals, birds, starchy plants and wood 125–250,000 years ago. *PLoS ONE*, 6, e23768.

- Hardy, K., Buckley, S., Collins, M. J., Estalrich, A., Brothwell, D., Copeland, L., et al. (2012). Neanderthal medics? Evidence for food, cooking, and medicinal plants entrapped in dental calculus. *Naturwissenschaften*, *99*, 617–626.
- Heim, J.-L. (1989). La nouvelle reconstitution du crâne néandertalien de La Chapelle-aux-Saints: méthode et résultats. *Bulletin des Mémoires de Société d'Anthropologie Paris*, *1*, 95–118.
- Henry, A. G., Brooks, A. S., & Piperno, D. R. (2010). Microfossils in calculus demonstrate consumption of plants and cooked foods in Neanderthal diets (Shanidar III, Iraq; Spy I and II, Belgium). *Proceedings of the National Academy of Sciences USA*, *108*, 486–491.
- Henry, D. O., Hietala, H. J., Rosen, A. M., Demidenko, Y. E., Usik, V. I., & Armagan, T. L. (2004). Human behavioral organization in the Middle Paleolithic: Were Neanderthals different? *American Anthropologist*, *106*, 17–31.
- Holloway, R. L. (1985). The poor brain of *Homo sapiens* neanderthalensis: See what you please. In E. Delson (Ed.), *Ancestors: The hard evidence* (pp. 319–324). New York: Alan R. Liss.
- Holloway, R. L., Broadfield, D. C., & Yuan, M. S. (2005). *The human fossil record: Brain endocasts—The paleoneurological evidence*. New York: Wiley-Liss.
- Hurst, J. A., Baraitser, M., Auger, E., Graham, F., & Norell, S. (1990). An extended family with a dominantly inherited speech disorder. *Developmental Medicine and Child Neurology*, *32*, 352–355.
- Krause, J., Lalueza-Fox, C., Orlando, L., Enard, W., Green, R. E., Burbano, H. A., et al. (2007). The derived FOXP2 variant of modern humans was shared with Neanderthals. *Current Biology*, *17*, 1908–1912.
- Lai, C. S., Fisher, S. E., Hurst, J. A., Vargha-Khadem, F., & Monaco, A. P. (2001). A forkhead-domain gene is mutated in a severe speech and language disorder. *Nature*, *413*, 519–523.
- Laitman, J. T., Heimbuch, R. C., & Crelin, E. S. (1979). The basicranium of fossil hominids as an indicator of their upper respiratory systems. *American Journal of Physical Anthropology*, *51*, 15–34.
- Laitman, J. T., Reidenberg, J. S., & Gannon, P. J. (1992). Fossil skulls and hominid vocal tract: New applications to charting the evolution of human speech. In J. Wind, B. Chiarelli, C. Bichakjian, A. Nocentini, & A. Jonker (Eds.), *Language origin: A multidisciplinary approach* (pp. 385–419). Amsterdam: Kluwer.
- Laitman, J. T., Reidenberg, J. S., Gannon, P. J., Johansson, B., Landahl, K., & Lieberman, P. (1990). The Kebara hyoid: What can it tell us about the evolution of the vocal tract. *American Journal of Physical Anthropology*, *81*, 254.
- Le Gros Clark, W. E. (1964). *The fossil evidence for human evolution*. Chicago: University of Chicago Press.
- Lev, E., Kislev, M. E., & Bar-Yosef, O. (2005). Mousterian vegetal food in Kebara Cave, Mt. Carmel. *Journal of Archaeological Science*, *32*, 475–484.
- Lieberman, D. E. (1998). Sphenoid shortening and the evolution of modern human cranial shape. *Nature*, *393*, 158–162.
- Lieberman, P. (1992). On the evolutionary biology of speech and syntax. In J. Wind, B. Chiarelli, C. Bichakjian, A. Nocentini, & A. Jonker (Eds.), *Language origin: A multidisciplinary approach* (pp. 391–397). Amsterdam: Kluwer.
- Lieberman, P., & Crelin, E. S. (1971). On the speech of Neanderthal man. *Linguistic Inquiry*, *2*, 203–222.
- Lieberman, P., Crelin, E. S., & Klatt, D. H. (1972). Phonetic ability and related anatomy of the newborn and adult human, Neanderthal man, and the chimpanzee. *American Anthropologist*, *74*, 287–307.
- Lieberman, P., Laitman, J. T., Reidenberg, J. S., Landahl, K., & Gannon, P. J. (1989). Folk physiology and talking hyoids. *Nature*, *342*, 486.
- Lohse, K., & Frantz, L. A. F. (2013). Maximum likelihood evidence for Neanderthal admixture in Eurasian populations from three genomes. *arXiv* 1307.8263.
- Marshall, J. C. (1989). The descent of the larynx. *Nature*, *338*, 702–703.
- Martínez, I., Rosa, M., Arsuaga, J.-L., Jarabo, P., & Quam, R. (2004). Auditory capacities in Middle Pleistocene humans from the Sierra de Atapuerca in Spain. *Proceedings of the National Academy of Sciences*, *101*, 9976–9981.
- Martínez, I., Arsuaga, J.-L., Quam, R., Carretero, J. M., Gracia, A., & Rodríguez, L. (2008). Human hyoid bones from the Middle Pleistocene site of the Sima de los Huesos (Sierra de Atapuerca, Spain). *Journal of Human Evolution*, *54*, 18–24.
- Maureille, B., & Vandermeersch, B. (2007). Les sépultures néandertaliennes. In B. Vandermeersch & B. Maureille (Eds.), *Les Néandertaliens: biologie et cultures* (pp. 311–322). Paris: Éditions du CTHS.
- McGrew, W. C., & Marchant, L. F. (1997). On the other hand: Current issues and meta-analysis of the behavioral laterality of hand function in nonhuman primates. *Yearbook of Physical Anthropology*, *40*, 201–232.
- Morin, E., & Laroulandie, V. (2012). Presumed symbolic use of diurnal raptors by Neanderthals. *PLoS ONE*, *7*, e32856.
- Peresani, M., Fiore, I., Gala, M., Romandini, M., & Tagliacosso, A. (2011). Late Neanderthals and the intentional removal of feathers as evidenced from bird bone taphonomy at Fumane Cave 44ky B.P., Italy. *Proceedings of the National Academy of Sciences USA*, *108*, 3888–3893.
- Peresani, M., Vanhaeren, M., Quaggiotto, E., Queffelec, A., & d'Errico, F. (2013). An ochered fossil marine shell from the Mousterian of Fumane Cave, Italy. *PLoS ONE*, *8*, e68572.
- Pettitt, P. (2012). Religion and ritual in the Lower and Middle Paleolithic. In T. Insoll (Ed.), *The Oxford handbook of the archaeology of ritual and religion* (pp. 329–343). New York: Oxford University Press.
- Quam, R., & Rak, Y. (2008). Auditory ossicles from southwest Asian Mousterian sites. *Journal of Human Evolution*, *54*, 414–433.
- Radović, D., Sršen, A. O., Radović, J., & Frayer, D. W. (2015). Evidence for Neanderthal jewelry: Modified white-tailed eagle claws at Krapina. *PLoS ONE*, e0119802.
- Rodríguez, L., Cabo, L. L., & Egocheaga, J. E. (2002). Breve nota sobre el hioides Neanderthalense de Sidron (Piloña, Asturias). *Antropología y Biodiversidad*, *1*, 484–493.
- Slimak, L., & Giraud, Y. (2007). Circulations sur plusieurs centaines de kilomètres durant le Paléolithique moyen. Contribution à la connaissance des sociétés néandertaliennes. *Comptes Rendus Palevol*, *6*, 359–368.
- Soressi, M., & d'Errico, F. (2007). Pigments, gravures, parures: les comportements symboliques controversés des Néandertaliens. In B. Vandermeersch & B. Maureille (Eds.), *Les Néandertaliens: biologie et cultures* (pp. 297–309). Paris: Éditions du CTHS.
- Soressi, M., McPherron, S. P., Lenoir, M., Dogandžić, T., Goldberg, P., Jacobs, Z., et al. (2013). Neanderthals made the first specialized bone tools in Europe. *Proceedings of the National Academy of Sciences USA*, *110*, 14186–14190.
- Vallverdú, J., Vaquero, M., Cáceres, I., Allué, E., Rosell, J., Saladié, P., et al. (2010). Sleeping activity area within the site structure of archaic human groups. *Current Anthropology*, *51*, 137–145.
- Vandermeersch, B., & Trinkaus, E. (1995). The postcranial remains of the Régourdou 1 Neanderthal: The shoulder and arm remains. *Journal of Human Evolution*, *28*, 439–476.
- Volpato, V., Macchiarelli, R., Guatelli-Steinberg, D., Fiore, I., Bondioli, L., & Frayer, D. W. (2012). Hand to mouth in a Neanderthal: Right-handedness in Régourdou 1. *PLoS ONE*, *7*, e43949.
- Zilhão, J., Angelucci, D. E., Badal-García, E., d'Errico, F., Daniel, F., Dayet, L., et al. (2010). Symbolic use of marine shells and mineral pigments by Iberian Neanderthals. *Proceedings of the National Academy of Sciences USA*, *107*, 1023–1028.